Wednesday Morning Poster Sessions, October 4, 2000

Organic Films and Devices
Room Exhibit Hall C & D - Session OF-WeP
Poster Session

OF-WeP1 Electrical Properties of Polyvinylidene Fluoride Films Prepared by Physical Vapor Deposition Method*, G.B. Park,* Yuhan College, Korea*; M.Y. Chung, S.W. Lee, S.H. Park, D.C. Lee,* Inha University, Korea

Poly Vinylidene Fluoride thin films were prepared by using a physical vapor deposition and high electric field applying method. Thin films were studied with DSC, FT-IR, X-ray diffraction and electrical conduction measuring system. The melting point of PVDF thin film increases with increasing substrate temperature. It is identified by FT-IR that the crystalline phase of @alpha@ type PVDF is transformed to @beta@ type with increasing electric field applied during preparation. It is found that the crystallinity of PVDF thin films increases from 49.8% to 67% with increasing substrate temperature from 30 to 80. The absorption current of @alpha@ and @beta@ type PVDF increases with increasing the electric field applied under measurement and the current increment of @beta@ type is higher than that of @alpha@ type. The ion hopping distance, derived from a relation between current density and measuring temperature, increases from 51.5 Å to 153.5 Å with increasing temperature. >From above results, the conduction mechanism of PVDF thin film is estimated as ionic.

OF-WeP2 Transport Gap and Polarization Energy at Metals (Ag, Au) - Organic Molecular Semiconductor PTCDA Interfaces*, W. Gao,* *A. Kahn,* Princeton University

The complexity of localization and polarization in molecular solids demands experimental determination of more reliable energy diagrams for charge carrier injection and transport phenomena than just from optical measurements. We use inverse photoelectron spectroscopy (IPES) and ultraviolet photoelectron spectroscopy (UPS) to investigate unoccupied and occupied electronic states of PTCDA (3,4,9,10 - perylenetetracarboxylic dianhydride) deposited on Ag. The interface shows metal-to-organic charge transfer and formation of polaron states. The relative shifts of the vacuum level and molecular levels were analyzed in the context of interface dipole model, extended to account for the evolution of polarization energy. The comparison between the splitting of the highest occupied and lowest unoccupied molecular orbitals (HOMO and LUMO) measured via UPS and IPES, and the optical gap measured via absorption measurements leads to an estimate of exciton binding energy E@sub e-h@ to be large (0.6eV), in accordance with the highly correlated nature of this molecular solid. We also use scanning tunneling microscopy (STM) and spectroscopy (STS) for PTCDA deposited on Au(111), and find results consistent with the UPS/IPES results. Work is supported by the National Science Foundation (DMR-98-09483).

OF-WeP3 Controlled Doping of Polycrystalline and Amorphous Molecular Organic Layers: Physics and Device Prospects*, X. Zhou, B. Maennig, M. Pfeiffer, J. Blochwitz,* ***T. Fritz,*** *K. Leo,* TU Dresden, Institut fuer Angewandte Photophysik, Germany

Organic dyes with a conjugated electron system are currently investigated intensively for optoelectronic applications. In contrast to classical silicon technology, the materials used for both research and devices such as organic light-emitting diodes (OLED) are usually prepared in a nominally undoped form, leading to scattering of device parameters and higher operating voltages as compared to e.g. polymeric devices. Shifting the Fermi level towards the transport states by doping can reduce ohmic losses, ease carrier injection from contacts and increase the built-in potential of Schottky- or pn-junctions. We present here the results of a comprehensive study of controlled p-type doping of various polycrystalline and amorphous organic materials by the strong organic acceptor F4-TCNQ (tetrafluoro-tetracyano-quinodimethane). It turns out that doping is more efficient for the polycrystalline materials like the phthalocyanines where doping enhances the conductivity by up to eight orders of magnitude (10@super -2@ S/cm). Nevertheless, we could show for the first time that also amorphous phthalocyanine layers (deposited onto cooled substrates) and amorphous wide-gap materials can be doped, i.e. their conductivity increases and their Seebeck coefficient decreases indicating a shift of the Fermi level towards the hole transport state. Amorphous wide gap materials like TDATA or TPD are commonly used as hole transport materials in OLEDs because they form smooth and stable layers. We show here that controlled intentional doping of these layers strongly reduces the operating voltages of OLEDs.

OF-WeP4 Cascade-Like Hybrid Organic-CdS Quantum Particle Architectures Studied by the Attenuated Low Energy Photoelectron Spectroscopy*, A. Samokhvalov,* *M. Berfeld, M. Lahav, R. Naaman,* Weizmann Institute of Science, Israel*; E. Rabani,* Tel Aviv University, Israel

Hybrid organic/inorganic matrices containing CdS quantum particles (QP) arranged in periodic layers separated by bilayers of arachidic acid/thioarachidic acid were prepared by Langmuir-Blodgett deposition on gold substrate. Within each layer, the QP are of the same average size of about 2.5 or 5nm, and the layers are arranged in cascade-like pattern. Electronic properties of the structures above were studied by the Attenuated Low Energy Photoelectron Spectroscopy in which a "pump" laser excites QP and a "probe" laser ejects photoelectrons either from gold or from the QP. This spectroscopy provides detailed information on electronic states of the QP and shows that they depend on the specific organization of the QP within the matrix, as well as on the interaction of the QP with the underlaying gold substrate.

OF-WeP5 Photoemission Investigation of Metal/CuPc Interfaces*, L. Yan,* *Y. Gao,* University of Rochester*; M.G. Mason, C.W. Tang,* Eastman Kodak Company

Metal/organic interface play an important role in organic light emitting diodes (OLED), which has been a very active field in the past few years because of their scientific and commercial significance. Copper phthalocyanine (CuPc) has been found to improve the electron injection when it is inserted as a buffer layer between the metal cathode and Tris(8-hydroxyquinoline) aluminum (Alq@sub 3@), the mostly used light emitting material in OLED. It is intriguing that CuPc, traditionally used as a hole transport material in OLED, can enhance electron injection at the cathode. To address this question, we investigated the formation and the energy level alignment at the interface between metals and CuPc, using X-ray and ultraviolet photoelectron spectroscopy (XPS and UPS) simultaneously. We found that unlike many other organic materials, CuPc has two components in C1s, whose relative intensity varies as the interface formation progresses. This property provides a unique avenue to determine the charge transfer, dipole formation and energy level alignment at the interface.

OF-WeP6 Photoemission Investigation of Energy Level Alignment and Chemistry in Al/CsF/Alq@sub 3@ Interfaces*, L. Yan, Y. Gao,* University of Rochester*;* ***M.G. Mason****, C.W. Tang,* Eastman Kodak Company

Organic light emitting diode (OLED) have attract great attention in recent years since the discovery of Tris(8-hydroxyquinoline) aluminum (Alq@sub 3@) based devices. One surprising discovery is that certain kind of metal/salt complex such as Al/LiF forms excellent cathode for electron injection, which is comparable in device performance to those made from low work function metal such as Li and Ca. However, Li has very small X-ray photoelectron spectroscopy (XPS) cross section, making it hard to investigate any possible interface chemistry. We have investigated the interface formation and energy alignment between Al/CsF and Alq@sub 3@, using ultraviolet photoelectron spectroscopy (UPS) and XPS simultaneously. The experiment result indicates that charge transfer to Alq@sub 3@ had occurred at the Al/CsF/Alq@sub 3@ interface, similar to Al/LiF/Alq@sub 3@ interface. While there is no reaction is detectable by photoemission between Al and LiF, there are significant changes in core level spectra between Al and CsF. On the other hand, the energy level alignment for the two systems is strikingly similar, which is consistent to the device performance studies. Based on these observation and simplified thermodynamic calculation, possible decomposition is proposed at the Al/LiF(CsF)/Alq@sub 3@ interfaces.

OF-WeP7 Scanning Tunneling Microscopy and X-ray Photoelectron Spectroscopy of Metal(Au,Ag) Deposited Alkanethiol and Alkanedithiol Layers*, T. Ohgi,* *W.-L. Deng, D. Fujita, H. Nejoh,* National Research Institute for Metals, Japan

The self-assembled monolayers (SAMs) of thiol molecules on Au(111) substrates have been extensively studied because of their easy preparation and potential for many applications. For example, in nano-electronics studies, application of the SAMs as a tunneling barrier@footnote 1@ is one of the attractive candidates since it is very easy to obtain widely spread, densely packed, well ordered and atomicaly flat surface and moreover, the thickness of the SAMs can be easily and exactly controlled by changing the length of the molecules. Electrical property of SAMs has so far been investigated by using a metal/SAMs/metal heterostructure, and their structural analysis has been mainly carried out by XPS, UPS, and ISS.@footnote 2@ In the previous study,@footnote 3@ we reported that in the case of SAMs of thiol molecules (HS(CH@sub 2@)@sub n-

1@CH@sub 3@: C@sub n@S), evaporated gold atoms penetrate through the SAMs. They cannot support metal overlayers, but monoatomic-height Au islands grow at the interface of the Au(111) substrate and SAMs. On the other hand, in the case of dithiol (HS(CH@sub 2@)@sub n@SH: C@sub n@S@sub 2@)layers, small Au particles are formed on them. In this paper, we show the result of Ag deposited octanethiol SAMs and alkanedithiol layers and discuss the difference from Au deposited ones. Ag atoms penetrate through both layers and do not form particles on them. The temporal change of Au particles/alkanedithiol/Au(111) structure were also studied. Sequential observation shows that particles penetrate through layers in weeks and form monatomic height islands under layers. @FootnoteText@ @footnote 1@ R. P. Andres, et. al., J. Vac. Sci. Technol. A14,(1996) 1178 @footnote 2@ D. R. Jung, et.al., J. Vac. Sci. Technol. A14,(1996) 1779 @footnote 3@ T. Ohgi, H. -Y. Sheng, H. Nejoh, Applied Surface Science 130-132, (1998) 919, T. Ohgi, H. -Y. Sheng, Z. -C. Dong, H. Nejoh, Surface Science 442, (1999) 277.

OF-WeP8 Wavelength- and Time-Dependent Two-Photon Photoemission Spectroscopy of the Dye Coated Silicon Surface*, A. Samokhvalov,* ***R. Naaman,*** Weizmann Institute of Science, Israel

Two dye molecules of similar structure, Rhodamine B and Sulforhodamine, were adsorbed on n- and p-doped silicon. The effect of photoexcitation of the adsorbed species on electronic properties of the surface of silicon was investigated applying the Wavelength- and Time-Dependent Two-Photon Photoemission Spectroscopy (WD-TPPE). It was found that the adsorption of Sulforhodamine, but not of Rhodamine B, causes a decrease in workfunction. For both dyes, the photoemission from the dye-covered silicon is reduced upon photoexcitation. The time-dependent recovery of the photoemission gets shorter for Sulforhodamine and longer for Rhodamine B, compared to the non-covered silicon. These observations are explained based on the electron donating properties of the molecules. In the case of Rhodamine B, photoexcitation of less than 10@super-4@ of the molecules on the surface was enough to affect the photoemission yield.

OF-WeP9 Structure and Molecular Recognition Ability of Thiolated-cyclodextrin Monolayer on Au(111) Surface*,* ***S. Yasuda,*** University of Tsukuba, Japan*; I. Suzuki,* Tohoku University, Japan*; K. Yase,* National Institute of Materials and Chemical Research, Japan*; J. Sumaoka, M. Komiyama,* University of Tokyo, Japan*; H. Shigekawa,* University of Tsukuba, Japan

Chemisorbed monolayers of thiols and disulfides on gold, so-called self-assembled monolayers (SAMs), have been studied to develop the novel interfacial systems. Since they easily form stable and highly packed monolayers, they are considered to have high potential to fabricate the micro-morphology of materials. From the point of view to develop a molecular recognition sensor using this technique, we analyzed structure and molecular recognition ability of the LP-@beta@-CyD (@beta@-cyclodextrin modified with lipoamide residue) monolayers formed on Au(111) surfaces, by using scanning tunneling microscopy (STM) and cyclic voltammetry (CV) measurement. The detailed adsorption process was completely different from that predicted from the macroscopic analyses. According to the macroscopic analysis, the growth process was explained by the Elovich model, which is based on the repulsive interaction between adsorbed molecules. However, many island structures were formed with the immersion time, indicating that the interaction between LP-@beta@-CyD molecules is attractive. Although the structure of the LP-@beta@-CyD molecules in the adsorbed layer was disorder, formation of the monolayer structure was clearly shown by STM. In order to examine the molecular recognition ability of the LP-@beta@-CyD/Au(111), we performed CV measurement using two electroactive makers; ferrocenecarboxylic acid (FCA) and hexacyanoferrate (HCF). FCA molecules can be included into @beta@-CyD cavity, but HCF molecules can not be. Therefore, if the monolayer structure is densely formed with the CyD cavity being perpendicular to the surface, the oxidation-reduction current is expected to be observed only for the case of the FCA molecules, which in fact was clearly shown by our experiment. These results indicate that the LP-@beta@-CyD/Au(111) structure has high potential as a novel molecular recognition sensor with its selective permeability. (http://dora.ims.tsukuba.ac.jp Appl. Phys. Lett., 76 (2000).)

OF-WeP10 Growth Modes of Vacuum Evaporated Pentacene on SiO2, MoS2 and Au Substrates*,* ***S. Zorba,*** *Q.T. Toan, N.J. Watkins, Y. Gao,* University of Rochester

Pentacene is one of the most widely used active material in organic thin-film transistors because of its remarkably high mobility. We studied the growth modes of vacuum evaporated pentacene on SiO2, MoS2 and Au substrates using Atomic Force Microscopy. Pentacene films were grown side by side on SiO2 and MoS2 substrates and separately on Au substrate by vacuum evaporation at room temperature with a deposition rate of 0.6 @Ao@/s. Pentacene films grow on SiO2 substrate in a layer by layer manner with full coverage at average thickness of 20 @Ao@ and have the highest degree of molecular ordering with large dendritic grains among the three materials. Films grown on MoS2 substrate reveal two different growth modes, ice-flake like growth and granular growth, both of which seem to compete with each other. On the other hand, films deposited on Au substrate show granular structure.

OF-WeP11 Analysis of the Surface Morphology of the Initial Growth Layers of p-quaterphenyl on NaCl (001)*,* ***E.J. Kintzel, Jr.***[1][2]*, E.A. Akhadov, T.W. Trelenberg, J.G. Skofronick, S.A. Safron, D.H. Van Winkle,* Florida State University*; F. Flaherty,* Valdosta State University*; D.-M. Smilgies,* European Synchrotron Radiation Facility

We have investigated the structural properties of the initial growth layers of p-quaterphenyl (p-4P) vapor deposited on NaCl (001) using Atomic Force Microscopy (AFM), Helium Atom Scattering (HAS), and X-Ray Grazing Incidence Diffraction (GID). The series of AFM studies provides evidence of needle-like accumulations of p-4P nucleating around surface defects, a striped-phase region with a lateral spacing of approximately 25 nm, and a region which displays a transition from lying to standing orientation of the molecules. HAS investigations at ~50K for films grown at 200K reveal many diffraction peaks which do not appear at the higher temperature. The helium diffraction pattern suggests the formation of randomly oriented micro-crystallites. Our GID studies indicate self-assembly of oriented crystallites in thin films. In thicker samples the diffraction becomes isotropic, like a powder pattern, indicating a random distribution of crystallite orientations.

OF-WeP12 Preparation of Stable Organic Layers Attached to Metals via a Double Bond*,* ***H. Oudghiri-Hassani,*** *M. Siaj, E.M. Zahidi, P.H. McBreen,* Laval University, Canada

New methods for preparing inorganic-organic interfaces lead to new types of functionalized surfaces. We describe a method to attach organic layers to a conducting solid via the formation of a carbon-metal double bond. The substrate is bulk molybdenum carbide, a material displaying metallic- like conductivity and ceramic-like hardness, as well as excellent catalytic activity. Early transition metal carbides are also of interest because they may form natural electrical contacts to carbon nanotubes in molecular electronics applications. The organic layers were formed by dissociatively chemisorbing carbonyl compounds on the carbide surface. By suitable preparation of the surface, and careful coverage control, layers stable to 1000 K could be prepared. The stability, structure and reactivity of these unprecedently stable layers were evaluated using several surface spectroscopies.

---

[1] **Morton S. Traum Award Finalist**

[2] **NSTD Student Award Finalist**

Author Index

Bold page numbers indicate presenter